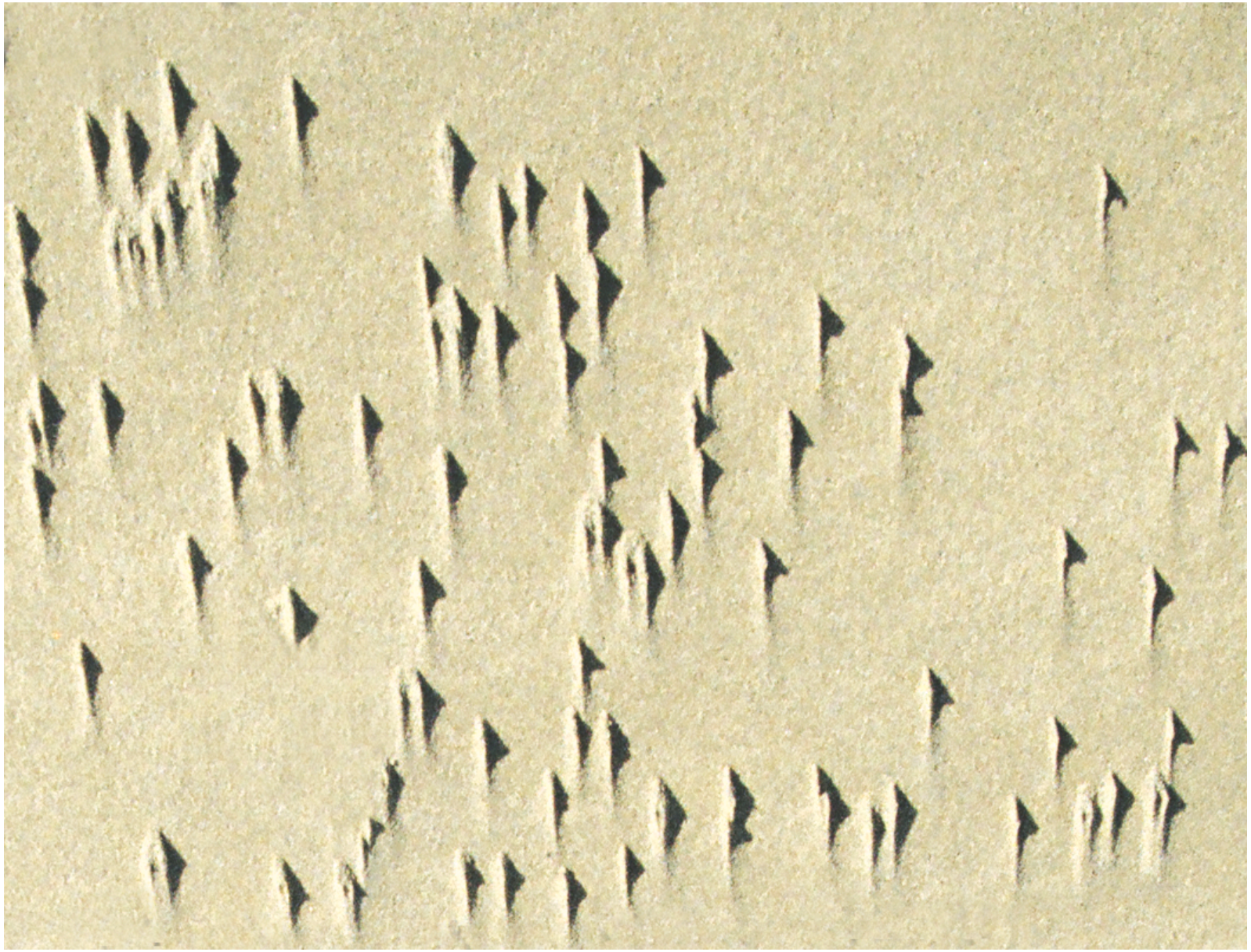


A new paradigm

NPRI Symposium

Nuclear Power and Global Warming

7-8 November 2005

J.W. Storm van Leeuwen

Ceedata

Key points

- Nuclear: free of greenhouse gases?
- How large nuclear share?
- How much uranium for energy?

Misconceptions

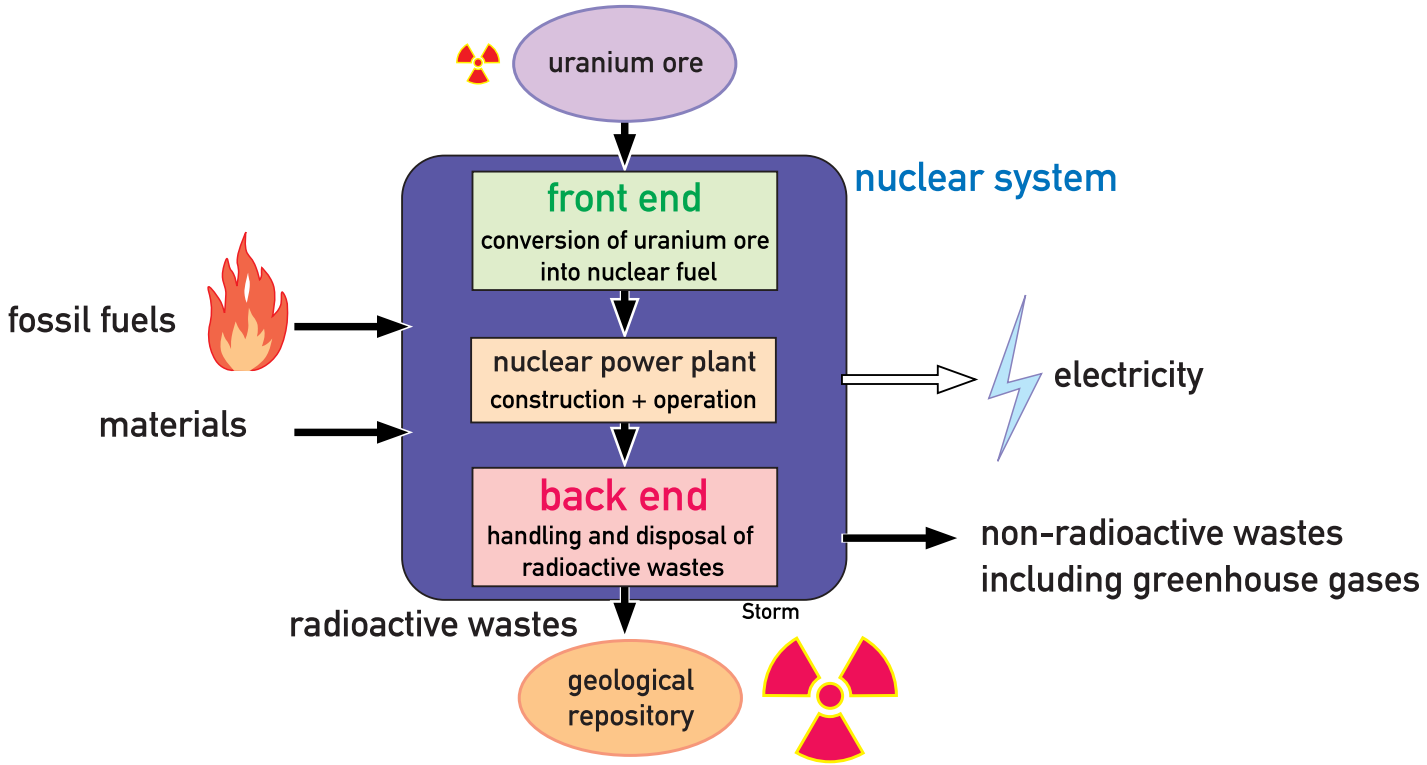
- Nuclear reactor = nuclear energy
- Enough electricity = enough energy
- Uranium = energy

Energy for energy

- Releasing useful energy from uranium costs energy

- Nuclear process chain
- Energy flows of the nuclear system

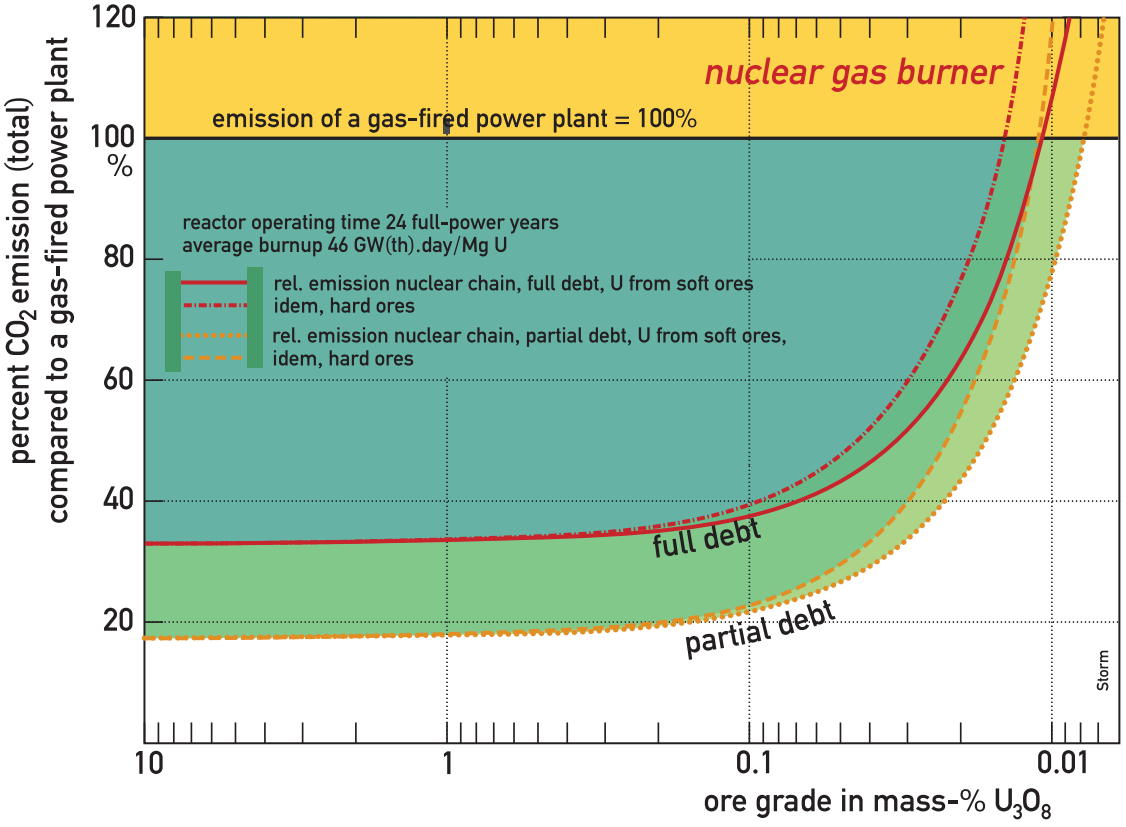
The nuclear process chain



1 Greenhouse gases

- Carbon dioxide CO_2
- Other greenhouse gases

Specific emission of carbon dioxide CO_2 by nuclear



Emission of other greenhouse gases

- Enrichment ~5 g CO2-eq/kWh freon-114.

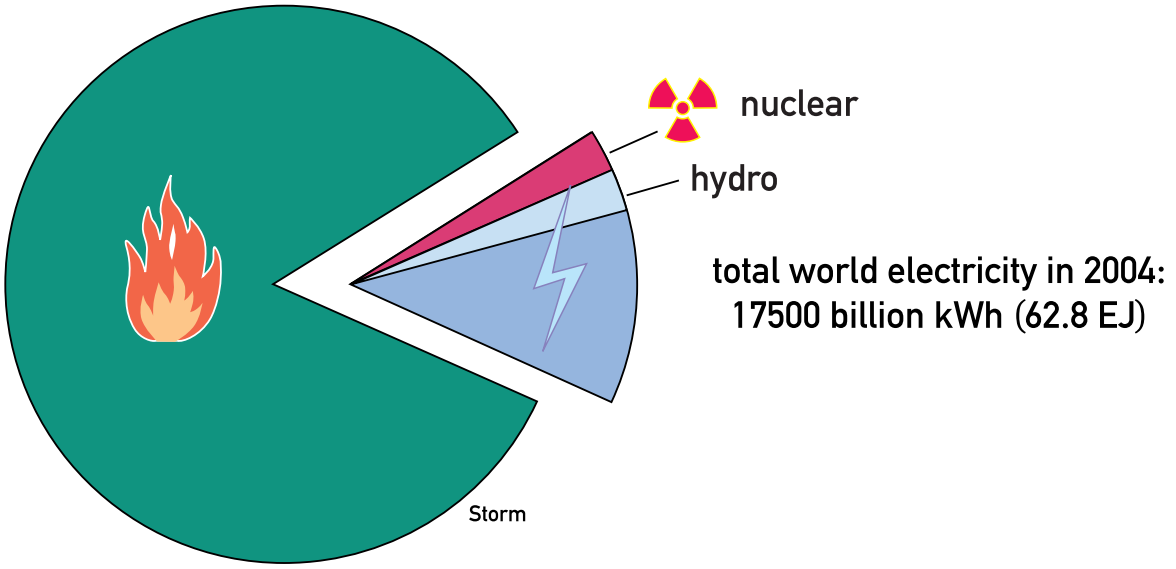
- Other greenhouse gases?
- All nuclear-related processes?

- Ever investigated and/or published?

2 Nuclear share in the future

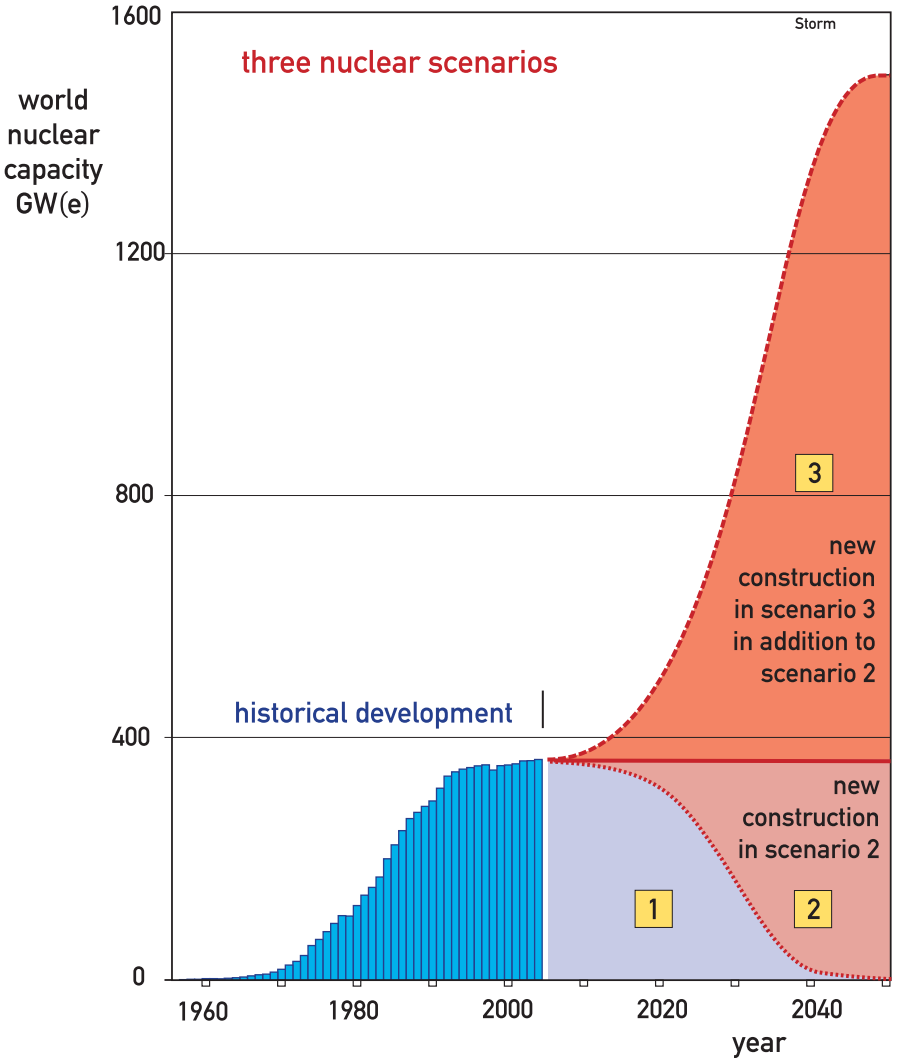
- Current share
- Nuclear scenarios
- World energy scenarios
- Uranium requirements

Current nuclear share

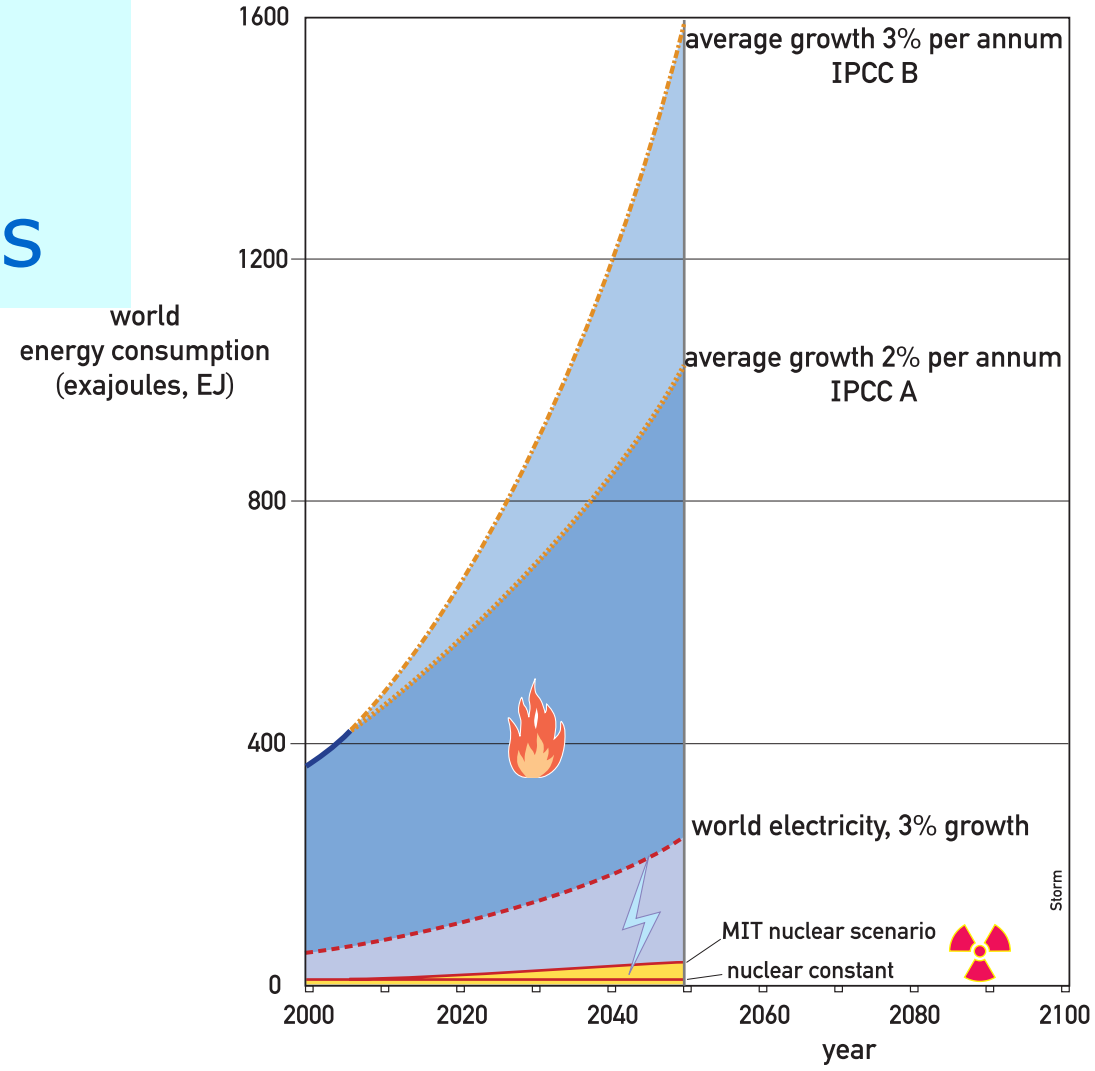


total world final energy consumption in 2004: ~400 EJ

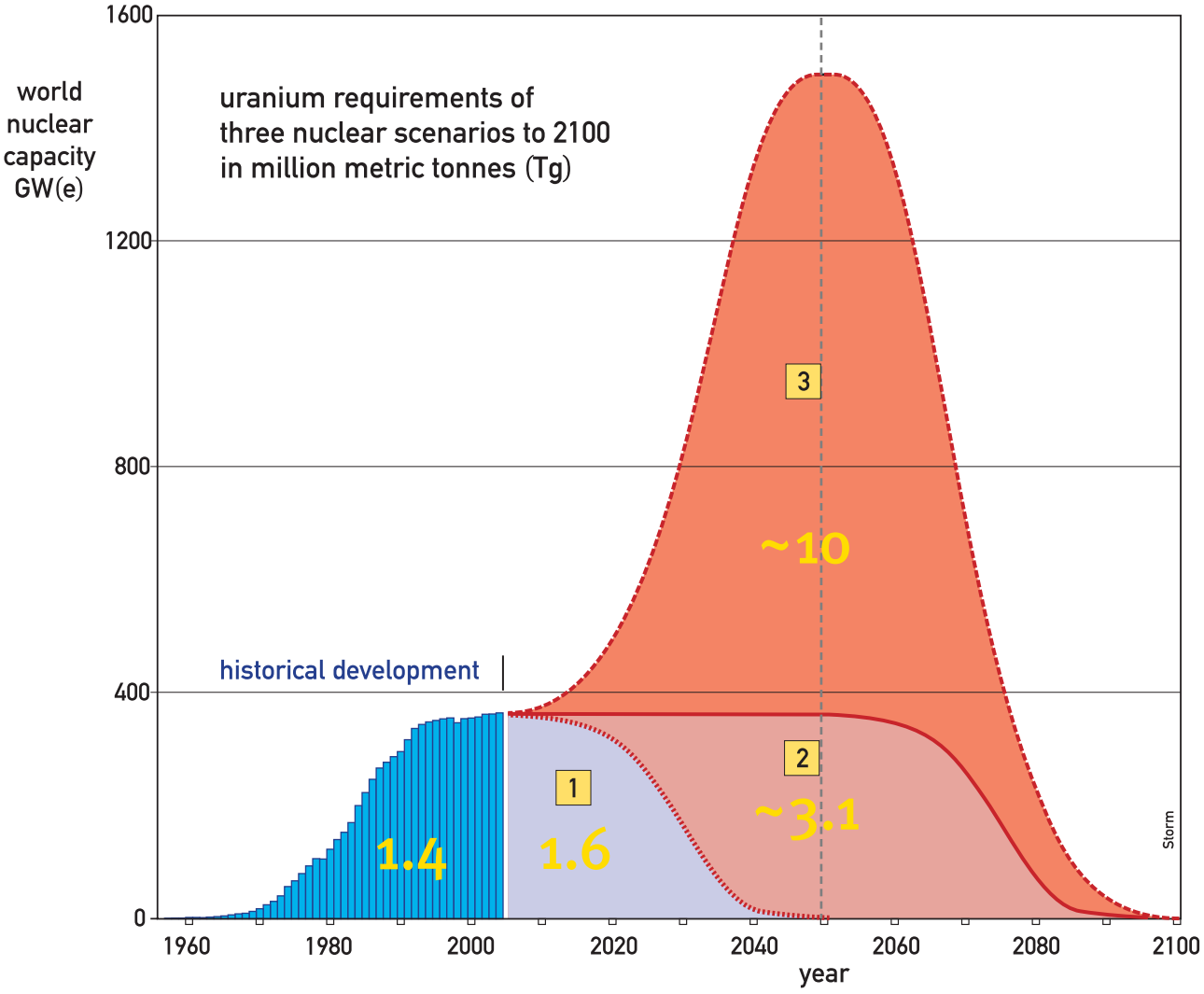
Nuclear scenarios



World energy scenarios



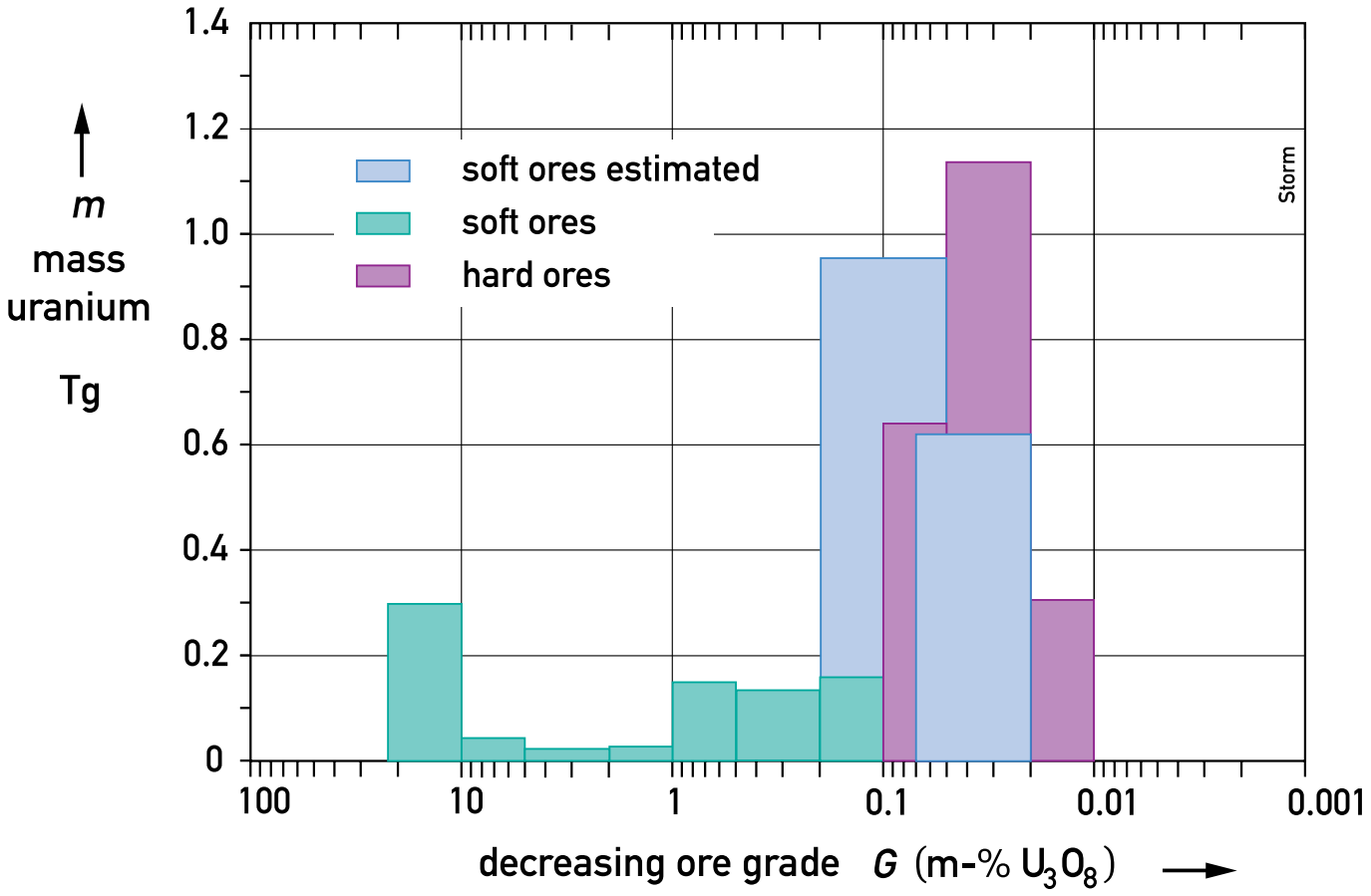
Uranium requirements



3 Availability of energy from uranium

- Uranium resources
- The energy cliff
- Nuclear energy resources

Quantities of available uranium depend on ore grade



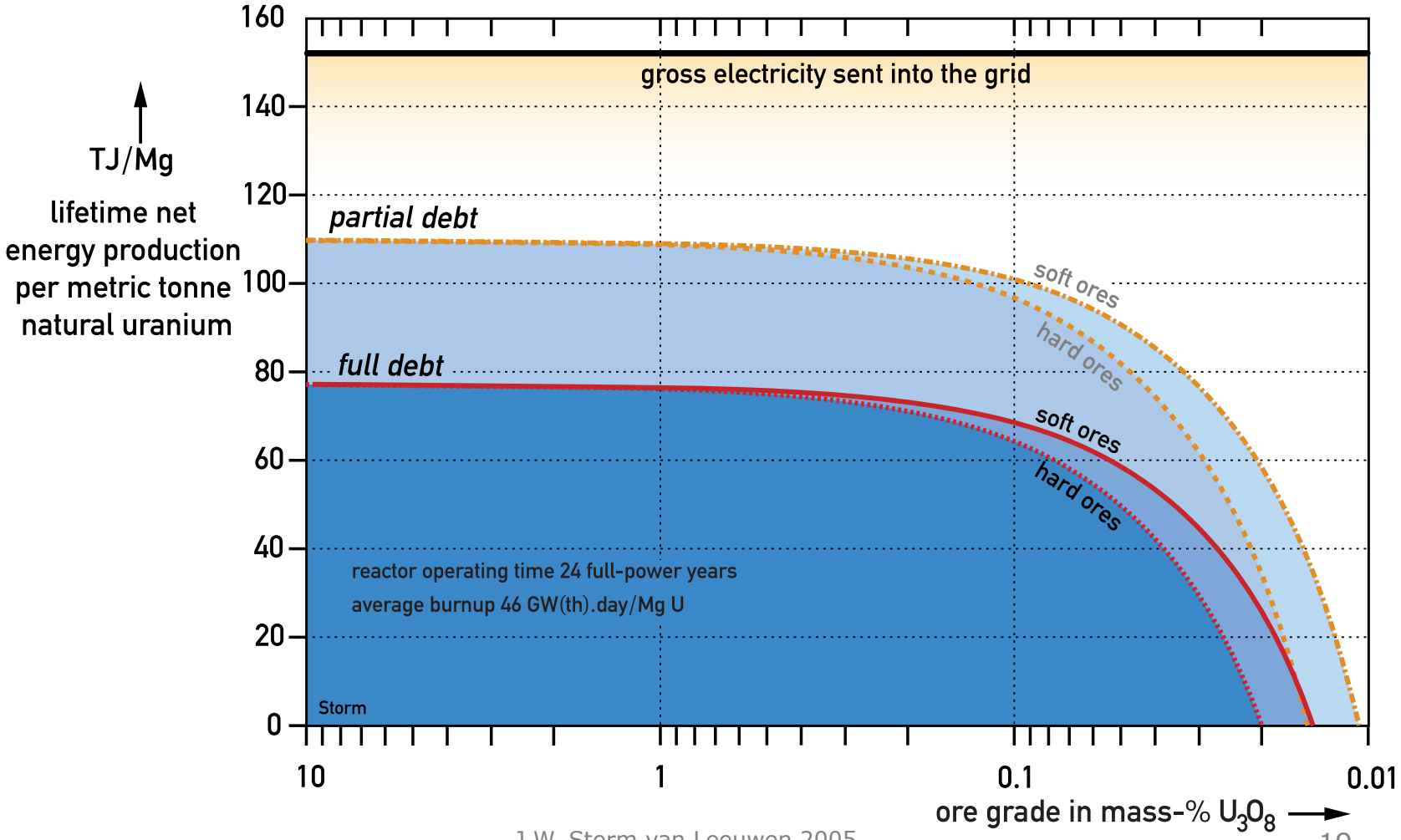
Uranium in the future: *economic view*

- Higher prices –>
- More exploration, advanced techniques –>
- More discoveries, lower costs –>
- More resources.

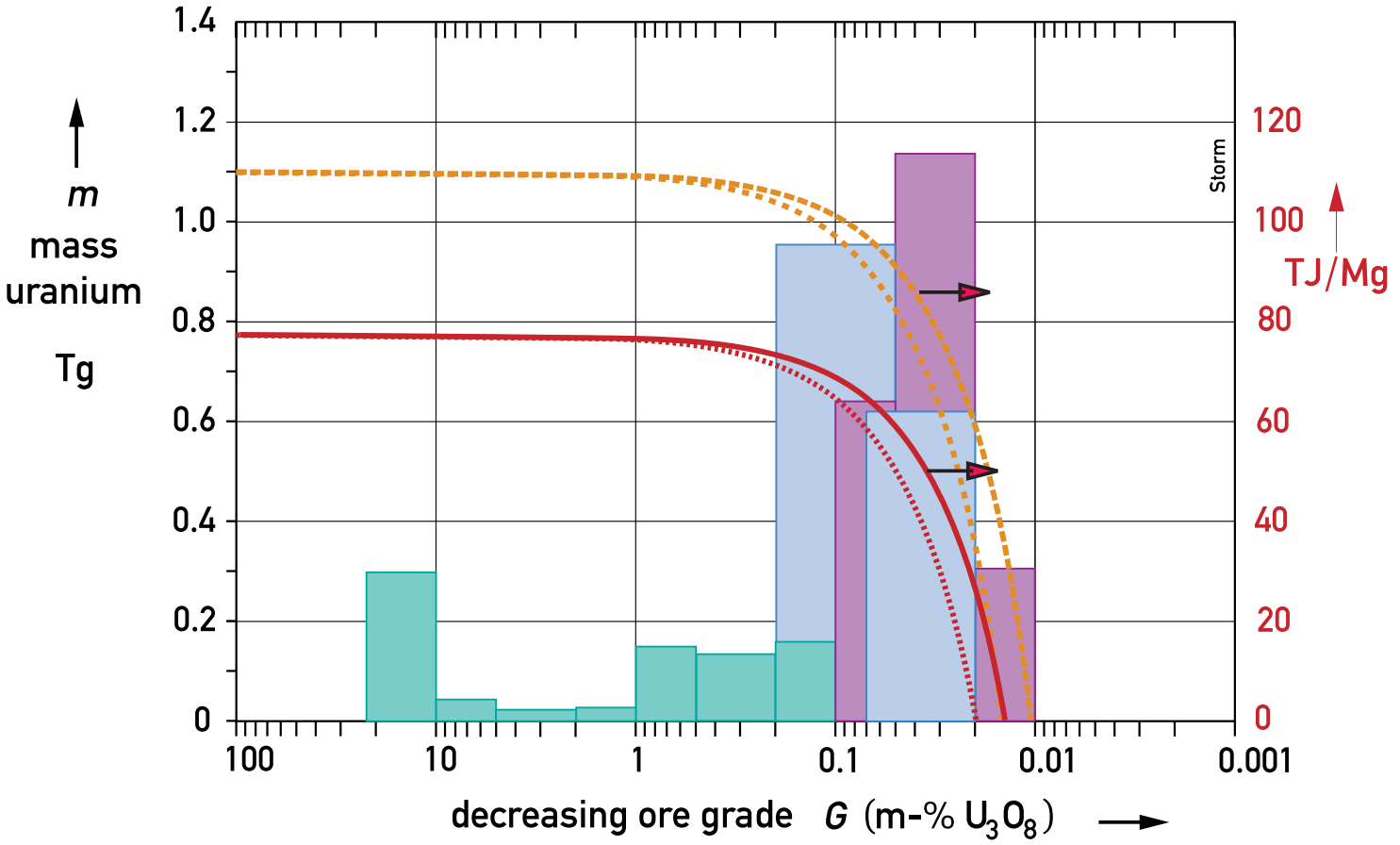
Uranium in the future: *physical facts*

- The larger amount of U in rock, the lower its grade.
- Easily discoverable and mineable uranium resources are already known.
- Physical laws stay in office, cannot be circumvented by economics.

The energy cliff



Nuclear energy resources



Conclusions

- Greenhouse gas emissions by nuclear?
  Yes. Carbon dioxide and other
- Nuclear share in the future:
  marginal to negligible
- Availability of nuclear energy from uranium:
  misconceptions
  uncertainties

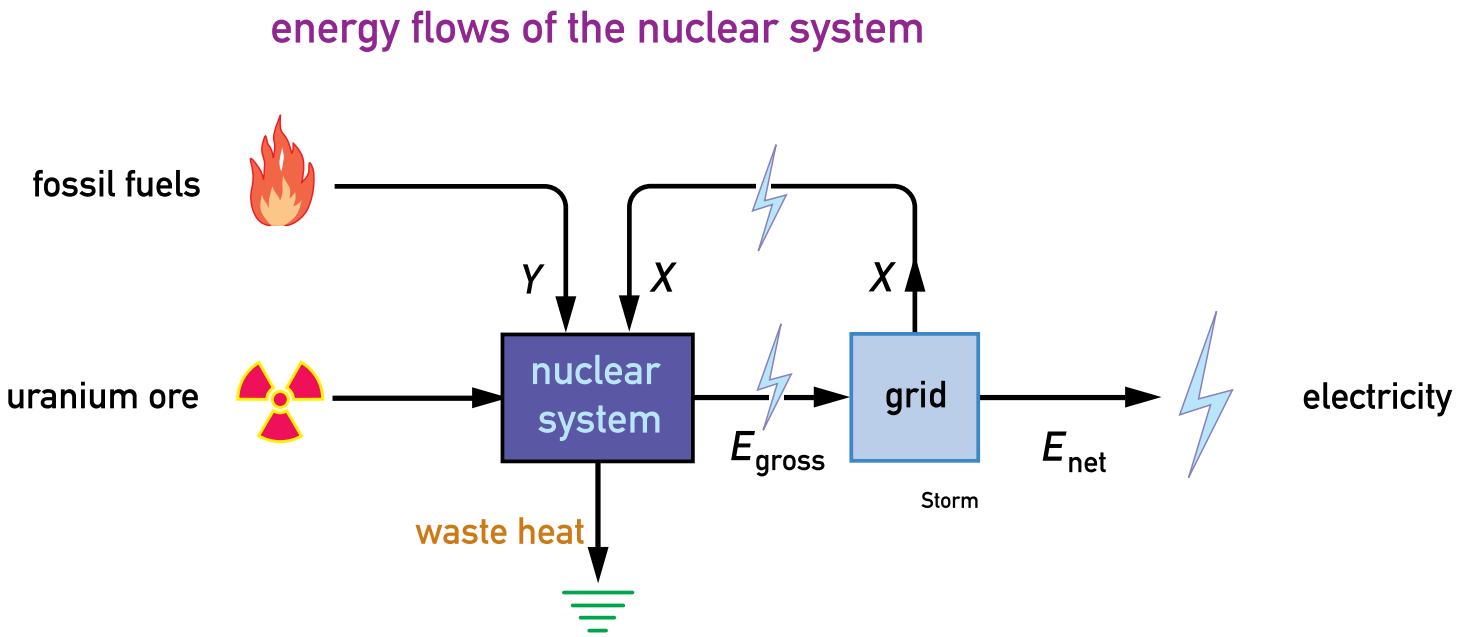
Concluding remarks

- For the same lifetime investments required for the nuclear renaissance scenario alone, the USA may become independent in its energy supply. Forever.
- All the USA need are sun, sand, wind and a new paradigm.

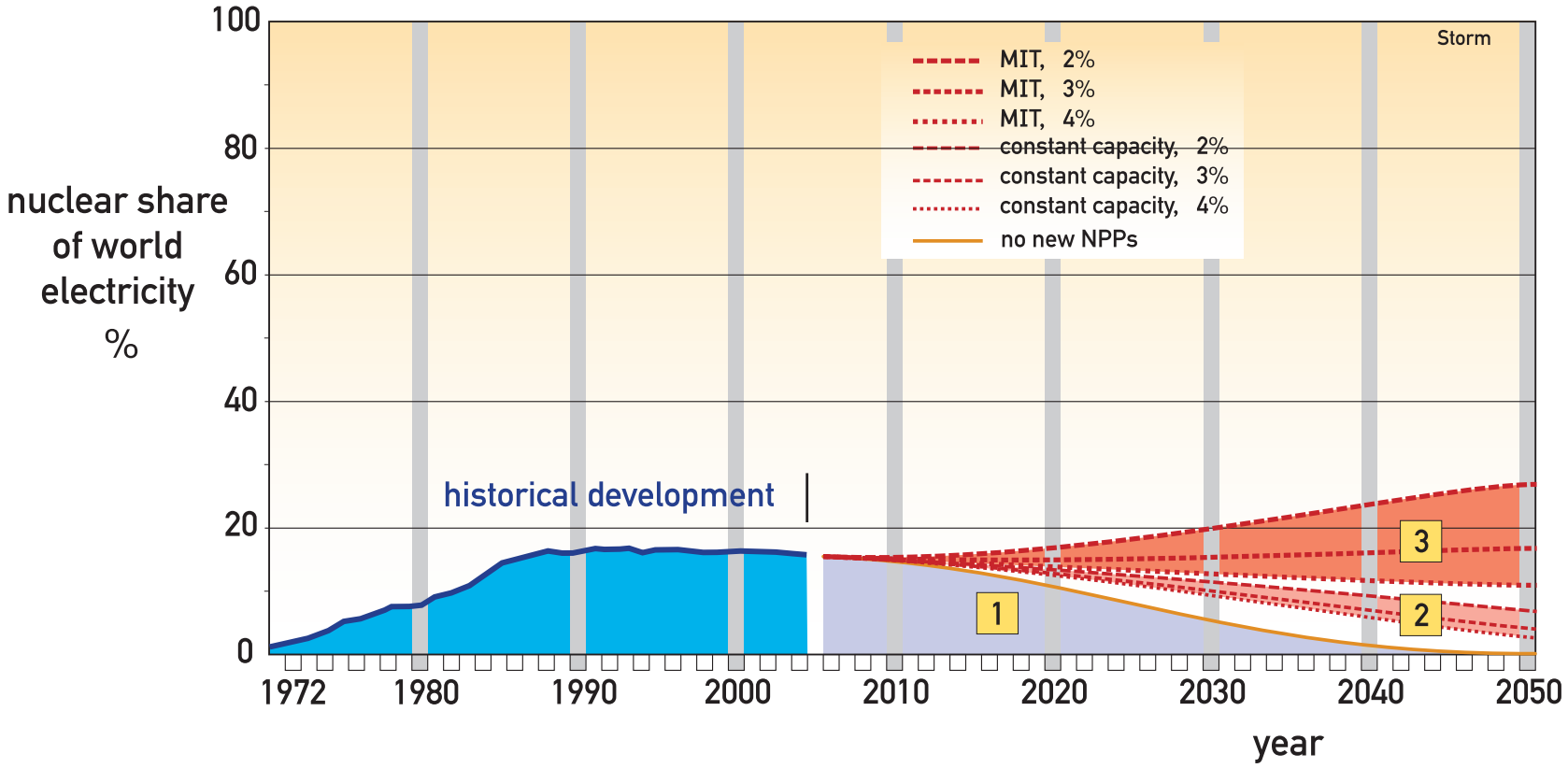
A new paradigm

- To cope with challenges ahead, a new paradigm is needed: a new way of thinking, in which complex thinking, long term aspects, physical laws and economic considerations are equally important.

Energy flows of the nuclear system



Nuclear share of world electricity



Greenhouse gases by nuclear

- Claims of GHG-free or carbon-free nuclear power are false.
- Specific emission is at least 70-150 g CO_2 / kWh, ~20-40% of gas-fired combined cycle power plants.
- Below uranium ore grade ~0.02% U nuclear plant becomes a gas burner.
- Emission of other greenhouse gases possible. From enrichment 5 g CO_2 eq/kWh.
- Total emission of GHGs, other than CO_2, as yet to be investigated.

Nuclear share in the future

- Currently 2.5% of world energy supply.
- Declines to less than 1% by 2050, if nuclear capacity remains flat.
- May reach 2-4% in most ambitious scenario (MIT).
- Possibly some kind of centrally planned energy economy required.

Nuclear energy resources

- Misconception:
  uranium resources not the same as *energy* resources.
- Beyond 'energy cliff' no net energy from uranium ore possible.
- 'Energy cliff' depends marginally on state of technology.
- Chances of finding new nuclear *energy* resources unknown.

Historical construction costs
nuclear power plants in the USA